

Figure 1

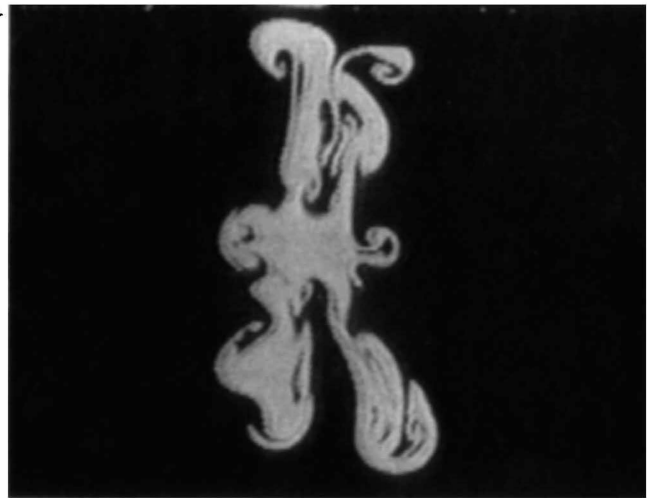


Figure 2

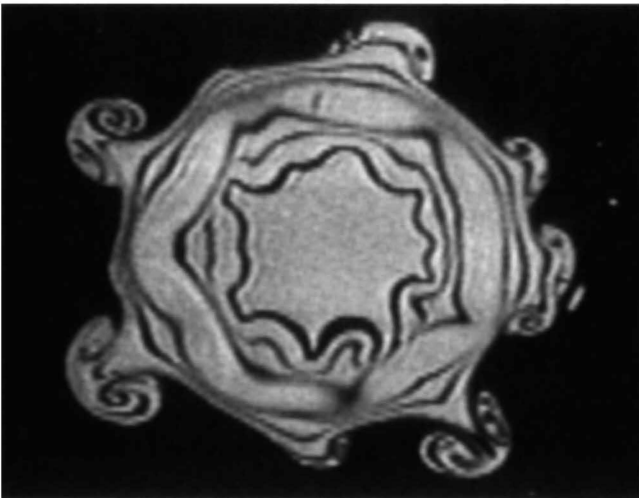


Figure 3

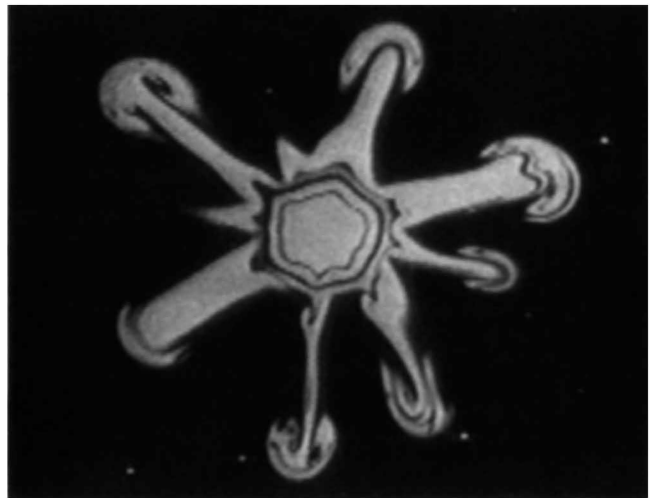


Figure 4

## THE EFFECT OF THE FREE SURFACE ON A ROUND JET

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The images shown above are sequential cross sections of a round jet at 3.5 diameters downstream of the nozzle visualized using laser-induced fluorescence. Figures 1 and 2 show the flow field of the jet 1 diameter below the free surface, while Figs. 3 and 4 are images of the submerged jet. Except for the presence of the free surface, the flow conditions are identical with a Reynolds number of 4000 based on the jet diameter and exit velocity.

Figures 1 and 3 are vortex rings followed by two images from the braid region before the next primary structures move through the laser sheet (Figs. 2 and 4). In the sub-

merged jet, the azimuthal instabilities grow evenly around the jet core. The secondary structures appear to grow in the braid region between the vortical ring structures that are the primary instabilities of the jet. The streamwise vortex pair that surround the vortex ring in Fig. 1 are attached to the downstream braid/ring structure but have moved out into the slower moving fluid and been left behind their original structure.

The free surface changes the dynamics of both the primary and secondary structures by reducing entrainment from above the flow and creating a stagnation point in the inward flow at the surface above the jet. The jet develops persistent vortex pairs at the top and bottom of the primary structures.

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